Development and application of spatially refined remote sensing active fire data sets in support of fire monitoring, management and planning

- Team Members:
  - W. Schroeder (PI)[UMD], J. Coen [NCAR], B. Quayle, P.J. Riggan & E. Hinkley [USFS], G. Rucker [ZEBRIS], E. Lorenz [DLR]
  - Acknowledgements: Will Walsh (programmer/UMD), NASA DRL & FIRMS

- Project Summary: Near real-time operational delivery of new spatially-refined remote sensing fire data (VIIRS 375m, Landsat-8, TET-1, Sentinel-2, BIROS) in support of fire diagnostics at landscape scales, and application in coupled weather-fire forecasting using NCAR's CAWFE model

Applied Sciences Program

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PI: Schroeder, Univ Maryland (wschroed@umd.edu, 301-314-1467)

Wildland Fire Program
ACTIVE PROJECT
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Purpose and Objective

Wildfire response at all government levels requires current and predictive fire information for tactical firefighting, evacuation, and strategic planning to avert or mitigate impacts. In this context, remote sensing active fire datasets, fire modeling tools, and associated geospatial products are essential to Forest Service and interagency fire operations. They provide critical support to fire managers and help inform the public in areas threatened by wildfires. This project builds on proven science algorithms to produce new spatially refined satellite active fire detection products that yield significantly improved fire monitoring information. In addition, these products are used to initialize and validate fire growth predictions in a coupled weather-fire model. The significance is that this approach can now be applied to monitor and predict the growth of a fire or a group of simultaneous wildfires in a management unit from first detection until containment – a previously unattainable goal due to accumulation of model error.

Societal Benefit Area(s): DIsasters
Geographic Focus: US (National)
Targeted End-Users: Fire Managers and Practitioners

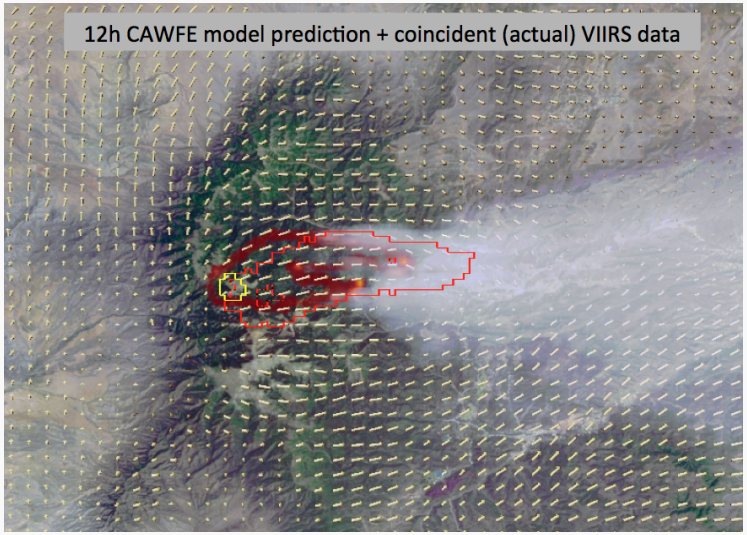

Figure: *CAWFE simulation of the 2012 Little Bear Fire. The yellow shape is the VIIRS fire perimeter used for initialization. The red shape is the VIIRS fire perimeter at the time of the simulation 12 h later*

Approach

New spatially refined satellite active fire products derived from VIIRS (direct readout), Landsat-8 (USGS) and Sentinel-2 (ESA) data will be processed by the USFS Remote Sensing Applications Center in Salt Lake City/UT and distributed to the broader fire user community through online data systems. Landsat-class near real-time data access options will be explored. Daily maps of satellite-detected fire activity will be frequently updated and used interchangeably to initialize a coupled weather-fire model (CAWFE). The model will enable complex fire behavior simulations including unique fire weather phenomena from ignition until extinction of large wildfires. CAWFE will be configured as a decision support tool, helping users identify priority areas for resource allocation based on analyses of multiple fire scenarios.

Key Milestones

Milestone Statement	Date
Porting of VIIRS fire algorithm to IPOPP operational package	06/15
Delivery of Landsat-8 fire algorithm	06/15
Delivery of Sentinel-2 fire algorithm	06/17
Test bed of CAWFE in simulated decision-making environment	12/15
Wx/Fire model integrated decision-making environment	12/16
Complete transfer of satellite codes to partner agencies, including training and customization	06/17
Transfer of CAWFE to additional outlets in govt. and private sector	8/18

$ARL_{Start} = 2$ $ARL_{Most\ Recent} = 7$ $ARL_{Goal} = 9$

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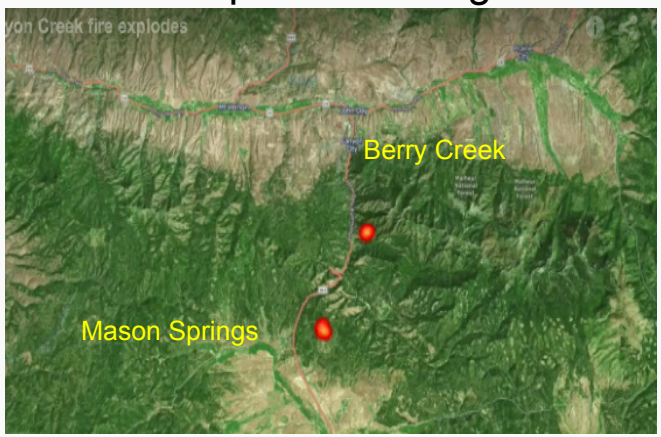
Take an example:

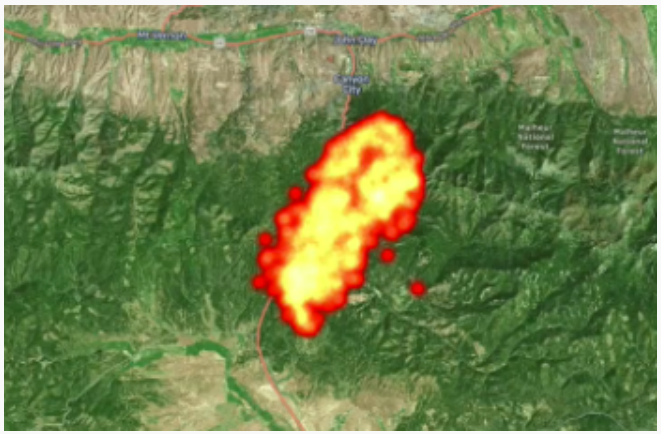
Canyon Creek Complex (2015) (OR)

Lightning storm passed over Malheur NF early hours of 8/12/15

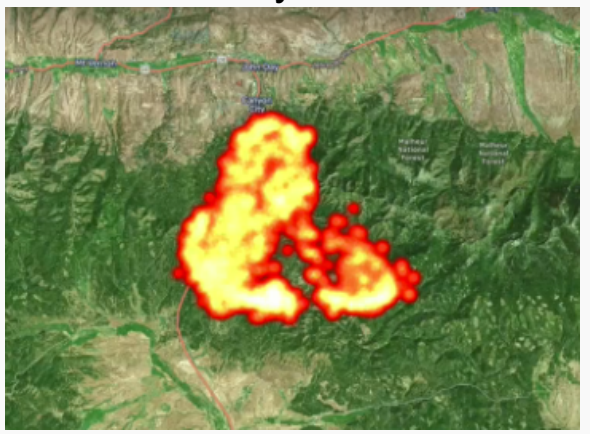
8/12 12 new lightning starts received initial attack. 2 escaped and merged



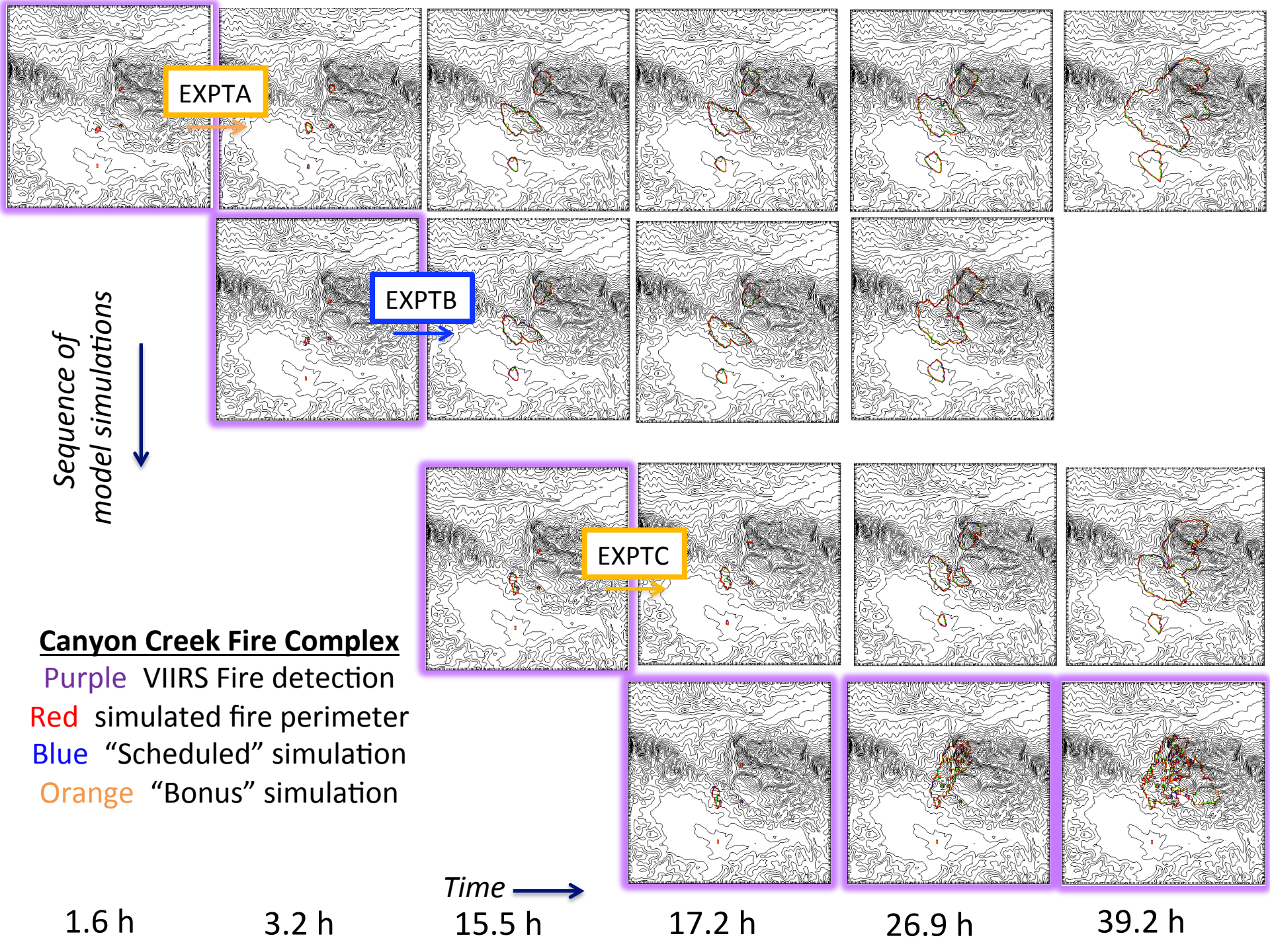
8/14 40 m.p.h. winds increased fire from 600 to 34,000 acres



8/14-8/15 Winds shifted and drove fire into Strawberry Wilderness



Imagery courtesy of oregonlive.com


EXPTA
EXPTB
EXPTC
Sequence of model simulations
Canyon Creek Fire Complex
Purple VIIRS Fire detection
Red simulated fire perimeter
Blue "Scheduled" simulation
Orange "Bonus" simulation
Time
1.6 h
3.2 h
15.5 h
17.2 h
26.9 h
39.2 h

Biggest Achievement or Advancement to Date

Project is promoting change in the way fire managers and practitioners perceive and react to satellite-based fire data and fire model simulations

Satellite active fire data:

- Previously during the EOS/MODIS era users would predominantly report discontentment with fire product performance. "*Why didn't MODIS detect the fire?!!*" was probably the most common feedback received
- Field validation campaigns would normally serve to document omission errors

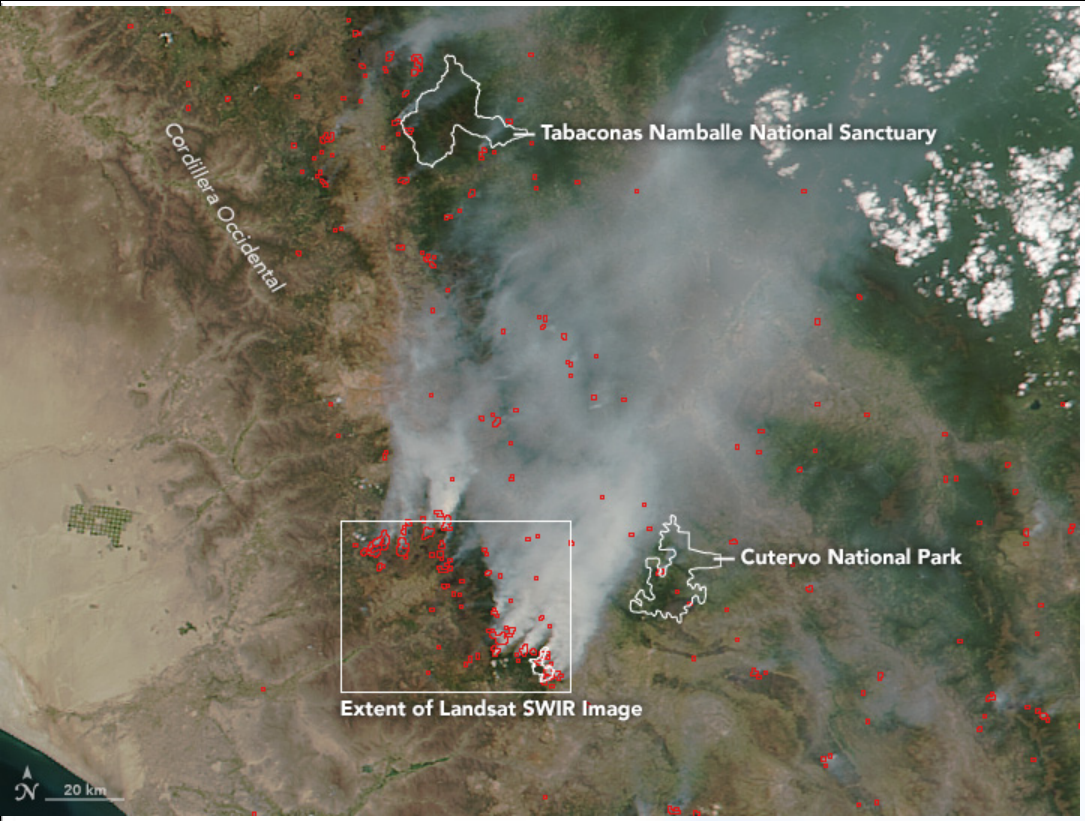
- New S-NPP/VIIRS, Landsat-8, Sentinel-2 fire data sets generating lots of positive feedback. "*Impressive*", "*excellent*" are some of the adjectives being used with the new data
- Field verification of new data producing encouraging findings

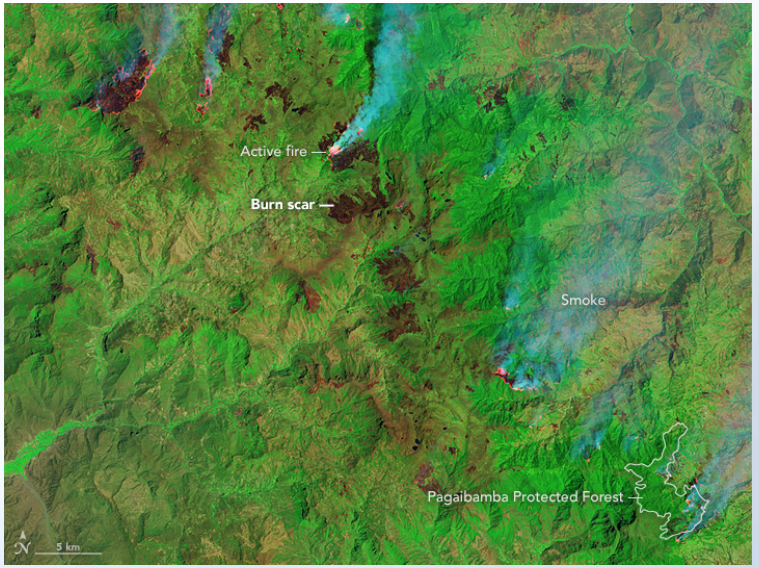
Wildfire simulations:

- Previously fire managers would confront fire behavior model simulations with great deal of skepticism. Fire simulations were subpar and end products would readily show their limitations

- CAWFE's coupled weather-fire model simulations are able to capture complex phenomena and generate accurate prognostics. Fire managers are quick to (positively) react to those simulations

User Feedback





Same-day (20 Nov 2016) Landsat-8/OLI image

"*We are seeing that the VIIRS fire alerts are a very powerful tool for precisely monitoring fires in near real-time in the Andean Amazon*" said Matt Finer, research specialist with the Amazon Conservation Association and director of MAAP.

Source: NASA Earth Observatory 14 Feb 2017
earthobservatory.nasa.gov/IOTD/view.php?id=89620&src=eoa-iotd

User Feedback

”Thailand Active Fire Products of SNPP-VIIRS Field Validation using 100 Fire Hotspots by FIRMS’ Alert Email System from 24 February to 24 March 2016”

“There were 100 cases used for field validation throughout the country. It was 98% accuracy where there were one false positive and one false negative.”

“The smallest burned area found was 2 by 2 square meters at LAT 10.784 N, LON 99.196 E Chumporn Province, Southern Thailand”

Credit: Veerachai Tanpipat

Major Challenges

How do we navigate a world of finite and often scarce resources?

Solutions:

(1)Highlight potential return on investment

(2)Balance immediate needs (e.g., putting fires out using current technology) and long-term ones (R&D)

(3)Less spending on Mars, Mercury, Saturn, black holes… and more on planet Earth!

New/disruptive technology can face opposition

Users need time to familiarize themselves with new data/tools

Natural selection takes time

Solutions:

(1)Emphasis on "*Adding to*" as opposed to "*replacing with*"

(2)Continued user outreach/engagement

PI Overall Assessment: Current Status

Summary of Challenges; Problems; Objective Analysis

- Partner agency enthusiasm doesn't always translate into adoption of new technology in an environment dominated by scarce R&D funding
- Convoluted internal procedures and/or bureaucracy can significantly impact technology transfer
- Problems upstream limiting data availability

Signs of Positive Progress

- S-NPP/VIIRS and Landsat-8/OLI fire products implemented operationally, growing user community
- Routine Landsat-8/OLI nighttime data acquisition/processing successfully implemented (first time!) in support of 2016 fire season
- CAWFE model fully demonstrated, CO fire initiative transitioning technology into operation; two additional outlets are in progress

PI Assessment: Transition Plan

Primary Goals:

- Develop spatially refined satellite active fire products and implement those at partner agency's (USDA/RSAC) near real-time operational system
  - Completed S-NPP/VIIRS and Landsat-8/OLI fire product implementation. Recently delivered an updated version including refinements/customization
  - Sentinel-2/MSI product development under way; source data characteristics/availability issues being addressed
- Apply coupled weather-fire modeling framework in decision support systems
  - Colorado fire initiative signed/funded. Modeling framework recently demonstrated/tested in operational mode

PI Assessment: Transition Plan (continued)

Remaining Steps:

- Addressing targeted product customization and improvements (e.g., higher level fire products)
- Continued outreach

Budget Status

- Rate of spending had to be reduced in order to accommodate competing projects and anniversary dates, a year of legislative/contract discussions
- Original project deliverables remain valid
- No-cost extension submitted 22 Feb 2017 – pending approval

PI Overall Assessment: Transition (continued)

Project implementation is progressing well and according to plan. No major red flags to report.

Colorado fire initiative introduced a series of contractual constraints generating conflicts with standard research practices (e.g., information security, rights to publish/present results)

Technology transfer has been successful although future maintenance/updates of new data sets and tools remain uncertain. Partner agencies may continue to depend on external R&D agents due to limited internal resources

$ARL_{Start} = 2$ **$ARL_{Most\ Recent} = 7$** **$ARL_{Goal} = 9$**

PI Overall Assessment: Impact

Honest Opinion

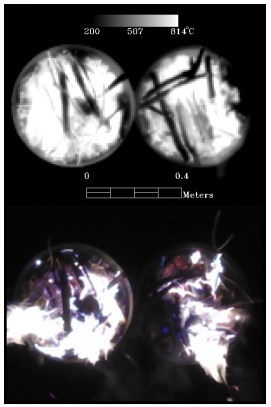
New VIIRS and Landsat-8 fire products have exceeded expectations, users embraced the data and applications have sky rocketed

Higher spatial resolution greatly improving field verification, lowering costs

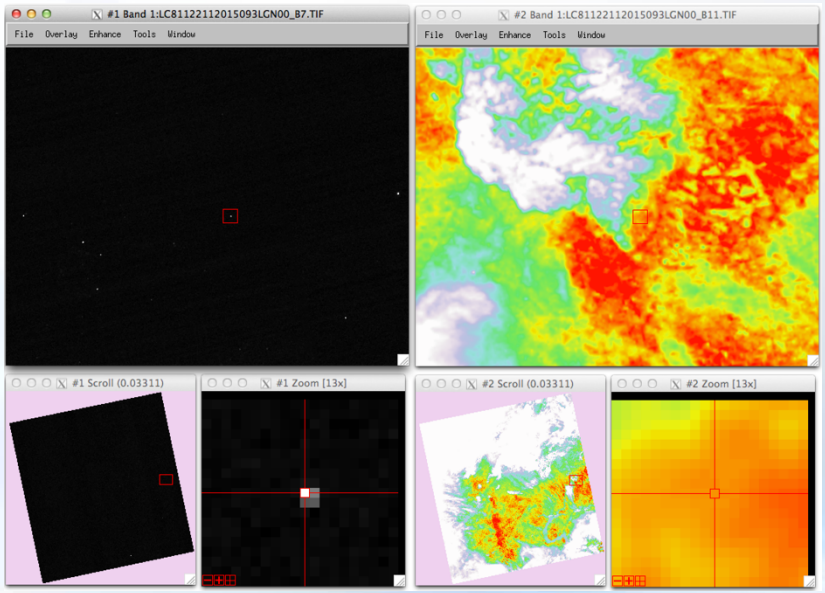
Coupled weather-fire model simulations have advanced long-standing paradigms. Cycling of satellite fire perimeter data allowed wildfires to be modeled throughout their entire lifetime

Project's Impact/Potential as an Analogy

Be careful what you wish for!!



When does "*small fire*" detection capability become noise?



Relevant Publications, Awards, Accomplishments

Publications:

•Coen, J. L., W. Schroeder, S. Rudlosky, Transforming Wildfire Detection and Prediction using New and Underused Sensor and Data Sources Integrated with Modeling. Proceedings Infobiotics/DDDAS Conference, Hartford, CT Aug 9-12. 16 pp. Springer. Submitted.

•Schroeder, W., Oliva, P., Giglio, L., Quayle, B., Lorenz, E., and Morelli, F. (2016). Active fire detection using Landsat-8/OLI data. *Remote Sensing of Environment*, doi: 10.1016/j.rse.2015.08.032

Primary data outlets

RSAC

LANCE FIRMS

FIRECAST

GLOBAL FOREST WATCH

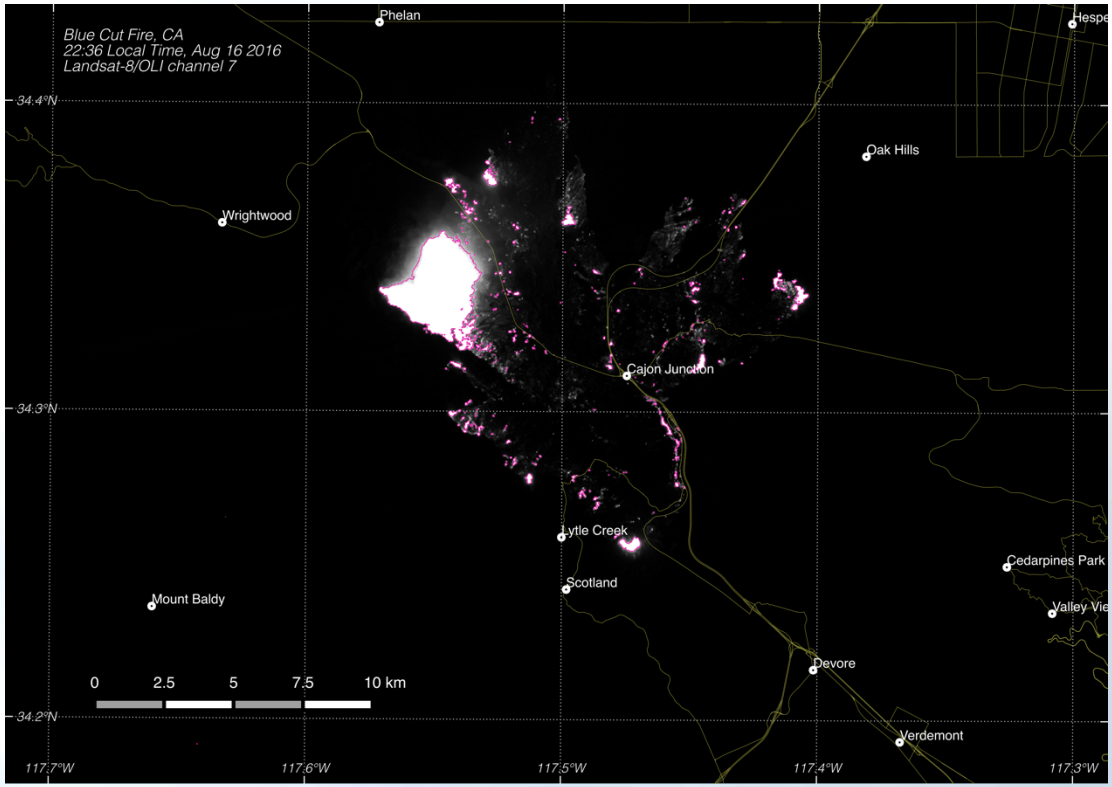
afis

INPE

CONABIO

EFFIS

CWFIS Canada



Coordination with USGS resulted in routine on-demand Landsat-8/OLI nighttime data acquisition and processing during Summer/2016 in support of fire management applications